Capability Improvements at the Arizona Radio Observatory

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1. Extended Abstract

In March of 2013, the Arizona Radio Observatory at the University of Arizona, began a program to upgrade the capabilities of its venerable 12-Meter radio telescope on Kitt Peak, Arizona through the acquisition of the European Southern Observatory's ALMA prototype antenna. Shortly after relocating the antenna from the VLA site in New Mexico to Kitt Peak, a program commenced to upgrade both the front-end receivers and back-end spectrometers.

Immediately after its dedication in November of 2014, development began on a 4 GHz wide digital FFT spectrometer. The two major requirements of the spectrometer were to match the 4 – 8 GHz IF of the receiver, and the ability to improve image rejection through the implementation of a digital signal processing algorithm. Since the ARO emphasizes spectroscopic observations, the capability to discriminate signals from the different mixer sidebands is paramount. Accurate wideband calibration and continuous response are other important requirements.

This lead to the desire for a high-speed, 8-bit analog-to-digital (ADC) converter. Two ADCs are required through a tightly coupled high speed field programmable gate array (FPGA). Curtiss-Wright, a US company that markets high speed digital products, had recently announced a product that contained a Xilinx Virtex-7 FPGA tightly coupled to two Tektronix 12.5 GHz ADC devices with sample and hold devices at the inputs. This combination proved to be a perfect fit for our application. A British Company, RFEL, provided the VHDL implementation of a high-speed pipe-lined 8192 point complex FFT. These two items became the basis for the ARO Wideband Spectrometer: AROWS.

After the antenna relocation, a single ALMA band 3 (3mm) receiver was assembled and installed as the workhorse instrument. This instrument has served the ARO well for the past 2 years, but having only one frequency band greatly limits the scientific capability of the new antenna. A new receiver is needed that can support multiple bands. A grant was obtained to develop a 4 band receiver for the telescope. This new receiver will cover the 3 atmospheric windows from 4mm to 1mm in 4 bands; three of which (1mm, 3mm, and 4mm), are ALMA bands. Each band will be contained in its own vessel clustered around the exterior of a rectangular prism Dewar containing the closed cycle cryogenic refrigerator.

The 4mm band receiver consists of a cryogenically cooled HEMT amplifier followed by a room temperature sideband separating mixer. The remaining bands, 3, 2, and 1mm, all utilize sideband separating SIS mixers. The 2mm band will use an in-house developed SIS mixer. The 3mm and 1mm band receivers use ALMA developed mixer components. Each band will have four IF outputs spanning from 4 – 8 GHz.

The second observatory operated by the ARO is the Sub-millimeter Telescope, (SMT), located on Mount Graham, Arizona. Its emphasis is sub-millimeter observation. Recent upgrades have improved the capabilities of the 1.3mm, 0.7mm and 0.5mm receivers with SIS mixers. Only the 0.5mm band uses a double sideband mixer, where the mixers in the other two bands use sideband separating mixers. All have dual orthogonal linear polarization capability. Another development program will provide a 0.8mm sideband separating mixer receiver along with dual orthogonal linear polarization.